STATISTICAL UNITS AS STANDARDS.*

By Horace Secrist, Ph. D., *Associate Professor of Economics and Statistics, Northwestern University.*

I. INTRODUCTION.

The requirement that statistics shall be comparable and the employment of statistical methods scientific is no less important, although it is undoubtedly more urgent, in times of war than of peace. We may hope for an end to war but we cannot expect the demands of statistical usage to be any less exacting. Never before has there been the same need as at present for an evaluation of accepted institutions, beliefs and methods, and for an appraisal of the rôle which statistical science is to play in the solution of world problems. Approximations, loose thinking, false judgments, crude comparisons, the mistaking of cause for effect, etc., because of ignorance, prejudice or a wilful desire to deceive, seem forever to be condemned in the searching criticism of realities which has come to us with the war.

Few fields of public or private activity seem to have escaped the demand for the creation of new standards. In the so-called scientific world, the slow processes of adjustment to new and changing conditions seem recently to have been greatly accelerated. In the business world where standards of measurements, uses, activities, etc., have not already been fixed and installed, either competition or state regulation is forcing their adoption. The scientific approach to economic and social problems seems to have caught public attention. Accounting has had its meteoric rise during the last decade and its cost aspects are rapidly coming into their own. The aim is clearly the introduction of scientific method, the appraisal of differences and similarities, the determination of cause and effect, all with the purpose of adjusting the processes of private and public business to the particular demands and needs of time and place.

The development of statistical methods in the interpreta-

*Paper read at the seventy-ninth Annual Meeting of The American Statistical Association.

tion of biological phenomena has been rapid. In the fields of business and social science, however, the growth has been slower, and of a more uncertain and unscientific type. Only recently has the popular assumption been in part dispelled that by "statistics" one can "prove anything." Even now the position of statistical methods is not secure nor are the uses to which statistics are put above serious criticism outside the laboratories and research fields of statistical students, the statistical departments of some of the more advanced government bureaus, and the more progressive private businesses. Statistical surveys and even statistical departments, in private and public business, are common, but that statistics are more than records of past activities,—collected not because of their relationship to future policy but rather because they are "comparable" with those already at hand—and that they may be made to supplement accounting in the formulation of rules and principles for future guidance, unfortunately have not become generally felt. Their present position is similar to that occupied by accounting ten years ago. People are not completely nor universally converted to the wisdom of their use, nor are they fully cognizant of the extent of their application.

The prejudice against both statistics and statistical methods, in part at least, is due to the following tendencies:

(1) To accept without serious question a plausible description of a given condition or state of affairs. *Ipse dixit* is often regarded as sufficient proof. The mere fact of statistics appearing in print, and particularly of their being in tabulated or graphic form—the finality of a statistical table or graph is often magical—is frequently sufficient to insure their value and to guarantee their application.

(2) To employ statistical data without knowledge of, or regard for the units of measurements in which they are expressed, or their comparability or representativeness, and to draw conclusions from them which they were never intended to support.

(3) To disregard detail, or to regard it as "detail" which somehow will take care of itself and needs no especial attention, to ignore statistical cautions respecting the collection of

data or the use of those already collected, to speak in terms of statistical abbreviations, averages of all types, to employ totals as if they were always more sacred and inviolate than the items which go to make them up, and to piece together statistical fragments, gleaned from different sources and compiled under widely different circumstances, into a beautiful mosaic which thoroughly proves or disproves a contention already held.

(4) To fail to formulate the purposes of statistical studies, to outline appropriate methods in order to serve the ends desired, to define with precision the units employed in the measurements, and rigidly to limit the field to be covered.

Statistics do not answer questions nor support conclusions independently of those who manipulate them. Judgment, candor, and integrity in their use are necessary at every step. The scientific development of statistical methods depends not only upon these but also upon a full realization of the meaning and function of units of measurements. It is statistical units as standards with which I shall deal in this brief paper.

II. UNITS AND STATISTICAL METHODS.

The statistical approach is numerical. Things, attributes, and conditions are counted, divided, subdivided, totalled and combined. Statistics are in large measure synthetic. They deal with aggregates, rather than single instances or rare occurrences. These, however, relate to units of measurements characteristic of things or conditions studied and apply to definite uses. It is not 1,000 as an abstract unit of frequency which is considered, but 1,000 farms, industrial establishments, loans, mortgages, etc. Numbers as abstract units may be combined, separated and divided because they are homogeneous, the more or less merely indicating presence or absence of a condition represented abstractly. But this is not true of units of measurements dealt with in statistics. The physical measurements of the unit "ton-mile," for instance, remain constant; but the qualities of the unit vary with each purpose for which it is used. A ton is invariably a ton and a mile a mile, but all tons, except as to weight, are not the same, nor are all miles, except as to length, equivalent. The problem

of enumeration is not so much that of counting units describing different degrees of intensity, abundance or absence of the same thing, as it is of counting different things which have been given the same general name. Things which are equal to each other in name are often not so in use. Standardization implies homogeneity; it suggests conformity and suitability to conditions determined in the light of particular application. The meaning of a statistical unit is a function of the use to which it is put. An illustration will give point to this contention.

It is desired to determine the industrial accident rate in a given industry as a basis for fixing a scale of compensation. What is an accident? The reason for compensation is the consequences of personal injury and it is the character of the injury which serves as a basis for enumeration. All injuries involving a loss of any time howsoever slight might be thought worthy of inclusion. But since compensation is the occasion for the determination of the number, only those injuries should be included which cause an *appreciable* loss of time. What is an appreciable loss of time? To an individual who experienced the loss, it might be any time, howsoever slight. To the employer, however, who advances the compensation, and to the public who finally bears it, a period of one or two weeks might be thought to be the minimum compensable period. But many trifling accidents may occasion a far greater loss of time than a single or a few serious ones. There would be no hesitancy about counting the serious, yet there might be respecting the minor ones. But it is precisely the latter which frequently can most easily be prevented, and about which information may be desired, since precautionary measures involving little added cost to the employer, increased efficiency to the employee, and the gradual elimination of the occasion for compensation, may be taken for their eradication.

Moreover, only industrial accidents are to be compensated. Self-inflicted injuries as well as those occurring to workmen while not engaged in industrial operations, and when work done is not a proximate cause of injury, should be eliminated, when accidents are enumerated for this purpose. Moreover, is disease contracted directly as a result of the conditions of industry an accident? Surely it is an "injury," and if injury

is the basis of compensation, ought not disease of this type to be counted in determining upon a reasonable basis? If disease contracted directly as a condition of employment is counted as an industrial injury (not "accidental," but characteristic or regular), how should instances involving impairment of health, mental or physical ability, be considered? How long a period must elapse before a condition, the result of employment, ceases to be checked against such employment? What is an industrial accident for compensation purposes?

On the other hand, if the purpose of enumerating industrial accidents were to measure the amount of time lost through mental or physical injury, obviously, all accidents and all diseases directly attributable to industry should be included. If the purpose were solely to secure information as a basis for removing the conditions causing accidents, or for assigning responsibility for them as between employer and employee, machine and injured person, those which were trivial, from the point of view of the individual, would take equal rank with those denominated severe. What is an industrial accident?

To formulate the purposes for which statistics are to be collected and used is the first step in statistical analysis; rigidly and unmistakably to define the units of measurements in which aggregates are expressed and to adhere to them throughout the process, is the second. The latter is governed by the former, as the former is determined by the latter. The two are reciprocal. Statistical units cannot be defined outside of the purposes of their employment, nor the purposes fully realized without the use of definite and standardized units of measurements.

The foregoing discussion will serve to make clear the distinction between the use of mass or frequency concepts in pure mathematical calculations and the use of the same concepts when associated with statistical units. Statistics is more than arithmetic. Numerical considerations and preponderance of evidence are the bases for statistical conclusions, but to arrive at them more than numerical computations are involved. It is concerned with the processes and methods of formulating and testing conclusions from premises resting upon numerical bases.

Leaving this more general discussion of the relationship of statistical units to the purposes for which they are used, certain types of units may be distinguished, and some of their peculiarities noted.

III. TYPES OF STATISTICAL UNITS OF MEASUREMENTS.

Distinction is drawn between *units of enumeration and estimation* and *units of analysis and synthesis.* The first are those by means of which statistics are collected; the second, those by means of which statistics are interpreted. The former are related more to statistics as numerical facts; the latter, more to statistics as methods in the use of these facts.

1. *Units of Enumeration and Estimation.*

Units of enumeration and estimation may conveniently be divided into two classes, *simple* and *composite.* By simple units are meant those in which one determining consideration is prescribed. Most statistics of enumeration employ simple units, as, for instance, where persons, animals, acres, etc., are counted or estimated. In units of this type the conflict between identity and use is reduced to a minimum. They are simple and this fact normally guarantees against the presence of as great a degree of error as is associated with units which are composite in character. The unit "farm," for instance, for a given purpose, might be easily defined and the statistics of "farms" readily understood. When, however, the limiting word "improved" is added, both the scope of the unit and its application are noticeably restricted. The additional element is as subject to error as is the root portion of the combined unit. Crops in bushels or in acreage may be readily determined; to establish the "normality" of these crops, however, raises other problems and calls for superior statistical organization and for a much greater exercise of judgment. New conditions enter, occasions for error and bias crowd in, and it is these to which attention is drawn in distinguishing between *simple* and *composite* units.

Moreover, the addition of a limiting word to a simple unit may change the meaning which the root carries when used alone. For instance, the unit "room," in a survey conducted

solely to determine the size of rooms in tenement buildings would be defined in such a way as to call for the listing of any portion of a house habitually used as a place of abode set off by walls with exits either closed or capable of being closed. To add to this unit the word "sleeping," suggests so many considerations respecting light, ventilation, size in respect to number of occupants, and time of occupancy, etc., as materially to alter the meaning attached to the unit when the counting was undertaken to determine size, but not size in connection with use.

The point which it is sought to emphasize is the fact that the identity of a statistical unit is a function of its use. For simple units, identity is established by general criteria; for composite units, by particular criteria. The more complex a unit becomes, the narrower is its application and the greater the necessity that its parts be standardized. Crude units may suffice for general impressions, but standardized measures are necessary for discriminating analysis. This is particularly true in cost accounting. Cost units must be reduced to their simplest and most elementary form. If composite or compound units are used, comparisons are likely to be misleading and their significance indeterminate. This fact is no less true in the use of statistical than in cost data.

2. *Units of Analysis and Synthesis.*

Both simple and composite units become *units of analysis and synthesis* when comparison or the establishment of relations follows from their use. Before classifying and discussing these, brief attention should be given to comparison and to what it implies statistically.

Comparison must be made between things possessing common qualities. These may be of time, of place, or of condition. For instance, the accident rate in a given industry may be compared before and after the installation of safety devices. Comparison may extend to two industries operating at different places or under different conditions, the purpose being merely to record a quantitative difference. But comparison is rarely made for this alone. Generally, a more or less definite purpose of establishing causal connection lies in the back-

ground. A specific inquiry is to determine whether phenomena stand in the relation of cause and effect, or whether they are the result of a common cause.

How nearly economic and business phenomena remain homogeneous for any appreciable period, even in an approximate sense, is always problematical. The forces affecting them are always in a state of flux governed as they are by population composition, state of trade, distribution of wealth, custom, fad, fashion, prejudice, etc. The whole range of human reaction is exhibited in more or less degree. Statistics under such circumstances often reveal a partial story, are not comparable from time to time and from place to place, and taken alone constitute a weak and uncertain base upon which to build a cause-and-effect structure.

Since comparison involves the pairing of things or events which are not identical in all particulars, a study of cause and effect, whether of coincidence or sequence, becomes largely a study of association. Causes never operate under exactly the same circumstances. Oneness of effect is only apparent, variation being evident the moment that the scale of measurement is reduced. Simply to assume the proviso "other things being equal" is not fully to atone for the sins committed in statistical comparisons. The "other things" are rarely if ever equal in actual life. Neither economic nor business phenomena go on indefinitely repeating themselves in one unending round of sameness. To expect that an absolute cause will always result in an absolute effect or that the "other things" will automatically take care of themselves is futile.

If comparison of economic phenomena is difficult, and the assignment of cause and effect rarely if ever absolute, the statistical units of measurements, by means of which comparisons are made, must be standardized according to use. Statistical comparisons involve the use of averages, of coefficients or ratios, in which enumerated or estimated numerators are related to enumerated or estimated denominators. To assign meaning to these without taking the trouble to determine the conditions which produce them or their suitability to the cases in point is as wrong statistically as it is logically to draw a false analogy. To do the first is to ignore the existence of deter-

mining circumstances; to do the latter to ignore their application.

The use of averages and coefficients as means of comparison suggests the formation of a judgment or a conclusion following from a full consideration of detail which they replace. Both represent the culmination of a process of thought and when removed from the steps required for their determination are likely to be assigned new meanings and used for purposes foreign to those for which they were designed. Neither should be regarded as a "secret something which determines events." They are simply statistical abbreviations into which are crystallized relations arrived at by logical processes of thought. Chronologically, they come late in the process of analysis.

Coefficients may be classified from two points of view; first, as *units of interpretation* and second, as *units of presentation.* Respecting the first: three subclasses, or more properly, three aspects may be distinguished, viz., those of condition, of time, and of place. The characteristic features of each subclass and the reasons for differentiating the concept in this manner may best be shown by means of illustrations.

(1) *Units of Interpretation.* By the use of clearly defined simple units of measurements, suppose the exact number of deaths from infantile paralysis, occurring in a given year, have been determined for a given district. The population of the same district has also been correctly enumerated or otherwise determined. The problem is to express the deaths from this cause in the form of a coefficient—to relate them to population. Obviously, the total population is too broad a base, since the particular cause of death is common to only a restricted group of the total. Conditions affecting both numerator and denominator must be made homogeneous. Similarly, industrial accident rates are of little comparative worth unless both frequency and severity are related to a standardized occupational exposure. If cost coefficients, in the business world, are to be significant, comparisons between stock turnovers, for instance, must be made only when classified sales at cost or selling price are related to classified stock reduced to corresponding bases. Likewise, labor turnover becomes a significant coefficient only when a unit of labor displacement is

related to a corresponding unit of labor force. Comparisons may be general only when the conditions upon which they rest have become standardized.

The distinction which is being emphasized is between crude and corrected coefficients. Crude rates are never to be preferred when corrected ones are available. Correction consists in more accurately defining, measuring and enumerating units and in referring phenomena rigidly to the conditions producing them. Where this is not done, the amount of error involved in comparisons is almost never known, and provision for it seldom possible.

Time and place are also factors of importance in the use of coefficients. A comparison of the death rates from malaria for the South and North is of little real value. There is little, if any, significance in a comparison of the number of miles of steam railroads per capita or per one hundred square miles of territory for New Jersey and Nevada. Why? The answer is clear; because the conditions are so widely different; the same phenomena are related to conditions wholly dissimilar or in each case of local application. Similarly, comparisons of the ratios of the number of bank failures to bank liabilities for the period before state and national regulations were inaugurated with the present time; of per capita city expenditures or debt of the 70's or 80's with 1917, are to a large degree without meaning. In the first case, regulation has so changed the conditions under which banking is done that there is little in common between the earlier and later periods; in the second case, the respective domains of public and private initiative differ so radically that a consideration of the amount of expenditure divorced from the benefits accruing from it is without merit.

Too great care can not be taken to make comparisons legitimate. This is particularly true in the case of statistical comparisons, since they are numerical and seemingly exact. A statistical statement is often taken by the unwary and uninitiated, as sufficient proof of its absoluteness and finality, and is made to support predetermined conclusions or premises to which it has no relation. Too much faith is placed in the efficacy of statistics to "prove things." Reasoning from other

angles is too frequently dispensed with—if not utterly ignored —on the part of the uninformed when "statistics" can be utilized, notwithstanding the fact that they may have no application, may be incomplete, unrepresentative, and questionable in origin, and that the problem can not be understood by an appeal to its numerical side. Loose reasoning and hasty judgments are even less defensible when statistics are appealed to to support a contention than when they are ignored, for the reason that they seem to carry a finality and to suggest a nicety of conclusion not generally associated with a less precise method of approach.

(2) *Units of Presentation.* Coefficients may also be regarded from the point of view of *units of presentation.* This thought suggests classification or the art of arranging data into groups according to their common characteristics. "Performed consciously or unconsciously, the act of classification is indispensable to and accompanies every scientific inference. A mind is orderly or slovenly, according as it does or does not habitually and accurately classify the facts with which it comes in contact. The success of an investigation, the worth of a conclusion, are in direct proportion to the fidelity to this principle and the exhaustiveness with which the process is carried out."*

Loose thinking, mistaken emphasis, and the assignment of cause for effect, or vice versa, result from a denial or a violation of this principle. This truth is involved in all that is suggested in the term "standardization," and applies no less to statistical science than it does to business and economic procedure. It is the principle of orderly arrangement, and to violate it is as indefensible when dealing with statistical facts as when formulating, for instance, systems of cost accounts. A cost system which failed to distinguish between overhead and material costs could no more be defended than a statistical summary which grouped together facts of different properties. Combinations must be made on bases that are common, and classification must follow lines that are significant.

It is indispensable, if statistics are to function, to adopt those units of presentation which give facts vitality. Sta-

*Cramer, Frank, The Method of Darwin: A Study in Scientific Method, p. 88.

tistics collected, classified and tabulated without a well-defined purpose are seldom of much value because of the lack of care in their preparation and because of the absence of a controlling purpose in their presentation. Too frequently the unit groups are so broad, purposeless and indefinite that whatever value the facts may have had as collected, is lost by the failure to correlate the method of presentation with the purpose or function which they are to play. Thus we have death rates tabulated by districts so large that correlation of deaths with their respective causes in detail is difficult if not impossible. From an administrative point of view, such statistics are frequently worthless. Similarly, density of population —a common coefficient—becomes meaningless when assigned to so large a population and so diverse conditions as those comprehended in an entire city. Density as a coefficient is significant only where over-crowding is a problem. Again, it is of limited significance to know that the great majority of wage earners in the United States receive less than, say, $1,200 a year. What is necessary to know is the distribution and wages of those below this limit. The wages of a non-homogeneous class expressed as a total or as an average are of little significance in throwing light on such problems as the distribution of wealth, the basis for arbitration of wage disputes, standards for minimum wages, etc. Units for expression are generally too broad; the facts are related to conditions which are not homogeneous. Statistics in this form become more an end than a means to an end, more a goal than a process.

Too great an expense and insufficient time are the stock excuses given for failure to classify and present statistical facts in detail. The validity of these common excuses for inefficiency and statistical sinning is not always easy of determination, but it is clear that it is not money and time which constitute our gravest statistical needs, but coöperation, planning, correlation of activities, and above all an appreciation of the fact that statistics may serve not only as records of past achievement but far more significantly as guides for future activities. They find their chief justification in the manner in which they minister to our positive needs.

IV. CONCLUSION.

Our general conclusions respecting statistical units as standards both in definition and application may be summarized as follows: Units should be clearly and fully defined in the light of the uses which they are to serve, in keeping with the intelligence of those who are to use them, and in such form that overlapping conditions will be readily detected, misunderstanding difficult and employment specific. They should be rigidly referred to the conditions which produce them; should be homogeneous with respect to the purposes for which they are used, and employed with consistency and integrity. After all, in the development and use of statistical units as standards, as in all statistical processes, an appreciation of the meaning of scientific method and a willingness to be guided by its requirements are indispensable. If either is lacking, statistics and statistical methods are without a logical defense.